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# FILTERING UNDER AMBIGUITY FOR THE DEBRIS-TRACKING PROBLEM

**Abstract**

Consider a space object in elliptical orbit about the earth. If the location and velocity are known 3-dimensional vectors at an initial time $t = 0$, then the laws of Newtonian motion can be used to propagate the motion. Further, if any initial uncertainty in the state is represented by a Gaussian point cloud, then the point cloud can be propagated to represent future uncertainty. Uncertainty is simplest to treat if it remains Gaussian. However, the uncertainty in the in-track direction increases more quickly than in the cross-track direction, leading to propagated point clouds with a distinct curved "banana shape" in Earth Centered Inertial (ECI) coordinates. Other coordinate systems such as Keplerian or equinoctial coordinates are sometimes worse and never provide a complete solution to the problem.

In earlier work we introduced a new "Adapted STructural (AST) coordinate" system in which the propagated uncertainty of the state vector is approximately Gaussian under a wide range of conditions, such as low and high eccentricity, LEO and GEO orbits, and short- and long-term propagation. Since AST coordinates are approximately Gaussian, they are well-suited for an unscented Kalman filter to estimate iteratively the state from a sequence of angles-only measurements. Initial assessments indicate that this filter performs well. In this paper we shall extend the analysis of the filter to investigate its behavior under ambiguity, both when the identity of the object is uncertain and when the winding number is uncertain. The first sort of ambiguity is relevant when the propagated position of two or more objects in a catalogue are compatible with an observation. Winding number is relevant when the propagated in-track uncertainty is so large that we can not be sure how many whole orbits have taken place.